NRL Report 5680

SURFACE CHEMICAL METHODS OF DISPLACING WATER AND/OR OILS AND SALVAGING FLOODED EQUIPMENT

PART 2 - FIELD EXPERIENCE IN RECOVERING EQUIPMENT DAMAGED BY FIRE ABOARD USS CONSTELLATION AND EQUIPMENT SUBJECTED TO SALT-SPRAY ACCEPTANCE TEST

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Washington, D.C.

CONTENTS

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ABSTRACT

The surface chemical techniques previously developed in this Laboratory for the removal of oily and/or electrolyte contamination and the displacement of water from electrical and electronic equipment has been field tested in two major equipment recovery projects. One project was the reconditioning of electronic equipment damaged by water, smoke, and heat during the fire aboard the aircraft carrier CONSTELLATION, and the other was the removal of salt residues from airborne radar equipment after salt-spray environmental testing. Both operations were highly successful. In the course of the work additional cleaning techniques employing more aggressive cleaning chemicals were devised and fitted into the integrated salvage procedure in such a way as to obviate damage from overtreatment and eliminate electrolyte residues otherwise left by aggressive cleaning agents.

PROBLEM STATUS

This is an interim report; work on this problem is continuing.

AUTHORIZATION

NRL Problem C02-15
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INTRODUCTION

The surface chemical procedure developed in this Laboratory for the recovery of equipment exposed to sea water damage and to contamination by oil, smoke, or greasy aerosols (1,2,3) has been intensively tested in the laboratory under simulated field conditions. It has been shown to be a safe, rapid, and efficient method of removing organic contamination, salt residues, and water from electrical equipment, and particularly from electronic assemblies such as military transmitters and receivers. The recovery techniques have been demonstrated to interested personnel from the Bureau of Ships and the Bureau of Weapons.

The December 19, 1960 fire on the partly outfitted USS CONSTELLATION provided a large scale and severe test of the practical utility of these procedures. The present report describes the problems encountered and the degree of equipment recovery accomplished. It also outlines the technical modifications in the process required for the solution of problems arising from fire damage and from unavoidable delays in application of the salvage procedures. In addition, this report deals with field experience in the reconditioning of airborne radar gear after exposure to a 50-hour salt-spray environmental acceptance test.

RECOVERY OF EQUIPMENT FIRE DAMAGED ON THE CONSTELLATION

On December 19, 1960, the partly fitted aircraft carrier CONSTELLATION experienced a severe fire and further extensive damage from large volumes of New York harbor water pumped aboard during fire fighting operations. On December 21 the New York Naval Shipyard requested advice from cognizant Bureau of Ships personnel on procedures for the recovery of damaged electronic equipment, and after consultation with the Naval Research Laboratory it was arranged for NRL representatives to confer with appropriate personnel at the Shipyard on December 29 and 30.

It was found that burning electrical insulation and paint had produced a dense oily soot which coated every surface and penetrated every crevice in the affected part of the ship. There had also been some vinyl chloride sheathing applied as an outer protection for electrical cables; decomposition of this had contributed hydrochloric acid vapors and unstable organic chlorides to the soot deposit. The salt harbor water used for fire fighting had actually flooded only a small proportion of the equipment, but the heat of the fire had vaporized salt water to form sea salt aerosols which had reached every place affected by the smoke. After eight days it was evident that all metal components were corroding seriously. The unheated ship was water soaked and damp. Films of condensed moisture were detectable on many surfaces.

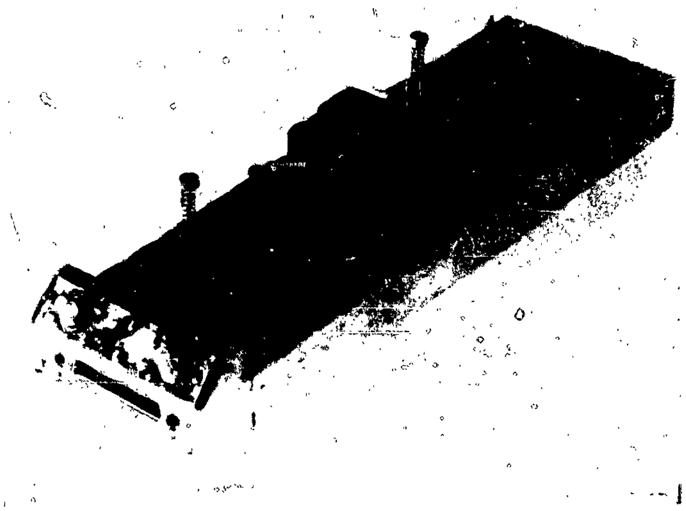
There was a wide range of damage intensity. The equipment in a few locations had been heat and flame damaged beyond possibility of salvage, but in most compartments the heat had been most intense about the cable installation next to the ceiling, so that paint was blistered only near the top of the electronic racks and cabinets, although soot and water had affected all levels. In many instances the electronic gear was found to have suffered no significant heat damage even when knobs, graduations, and legends on the control panel had been charred or obliterated. The NRL representatives used chemicals and ultrasonic equipment furnished by the New York Naval Shipyard to demonstrate the cleaning technique to shipyard personnel.

The frequency converter shown in Fig. 1(a) was selected for a preliminary test of the NRL recovery procedure. It was wet and covered with an oily coating of soot and salt aerosol. A 3-minute treatment with the emulsion cleaner (140°F flash naptha plus a little diesel fuel emulsified in water with a nonionic detergent) was followed by fresh water flushing with ultrasonic agitation and the equipment was drained. Treatment of the wet equipment with an aerosol spray of the water-displacing fluid (normal butyl alcohol plus a rust inhibitor) brought the piece to the condition shown in Fig. 1(b). Drying overnight at 140°F returned the converter to its electrical performance as received. Trials on more severely damaged items that had been tentatively marked for survey showed that most of these items also could be returned to operating condition, although external refinishing and refitting might be required. Because of the time that had elapsed since the fire, it was found that smoke residues had hardened and corrosion progressed to the extent that some items required pretreatment with an aggressive cleaner before application of routine salvage techniques. The results of this type of cleaning are shown in Figs. 2 and 3.

On the basis of these trail results, the representatives of the Bureau of Ships and New York Naval Shipyard decided to proceed with a full scale reconditioning program, and the Bureau issued an instruction (4) which authorized the use of the NRL salvage system. Actual recovery work was assigned to shipyard personnel.

The NRL representatives were asked to indicate equipment and materials required for the project and to serve as technical consultants for procurement of material and for the salvage operation itself. The consulting role required the services of one man for a major part of each working week for about three months and weekly visits by a another man during that time. As an immediate stopgap measure, the NRL consultants recommended that all of the equipment to be recovered should be liberally sprayed at once with the water-displacing liquid (commercially available as the aerosol preparation "Spradri"). This treatment displaced water, reduced corrosion, and resulted in easier eventual recovery. Components for the cleaning emulsion (see Appendix A) were procured locally, and an adequate supply of the water-displacing liquid was ordered from the manufacturer. Ultrasonic equipment was procured by the New York Naval Shipyard from the Westinghouse Electric Corporation and from Harris Transducer Corporation.

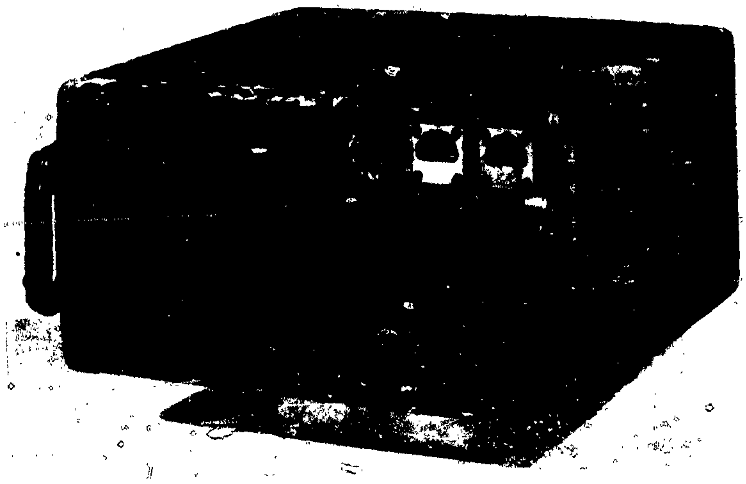
The Westinghouse unit consisted of a tank 6 feet by 30 by 36 inches and a 20-kc magnetostrictive transducer powered by a 10-kilowatt generator. The Harris magnetostrictive transducers were of the immersion type. One set of 4 transducers was submerged in each of two stainless steel tanks 36 by 36 by 36 inches constructed by shipyard personnel. Each set of four transducers was powered by a 1400-watt generator. Air drying of the reconditioned equipment was done in a walk-in air-circulating oven already available in shop 67. The temperature was adjusted from 125° to 150°F depending upon the equipment being dried. The NRL consultant briefed safety personnel and supervisors at New York Naval Shipyard on the nature of the fire and health hazards to be anticipated in production use of the salvage method, and necessary safety regulations were agreed upon and issued. The general plan of the recovery operation was as follows. Equipment, after



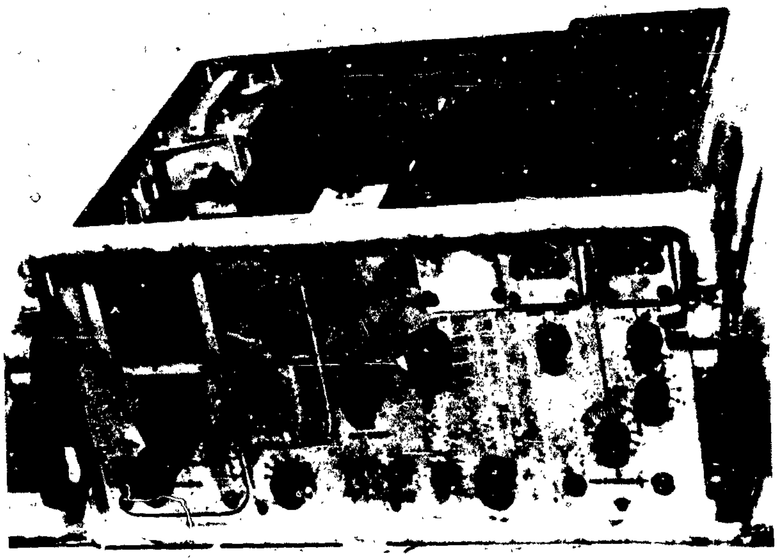
(a) - Appearance before cleaning

(b) - Appearance after cleaning

Fig. 1 - Frequency converted damaged by soot and smoke. (Pictures courtesy of Material Laboratory, New York NAVSHIPYD.)

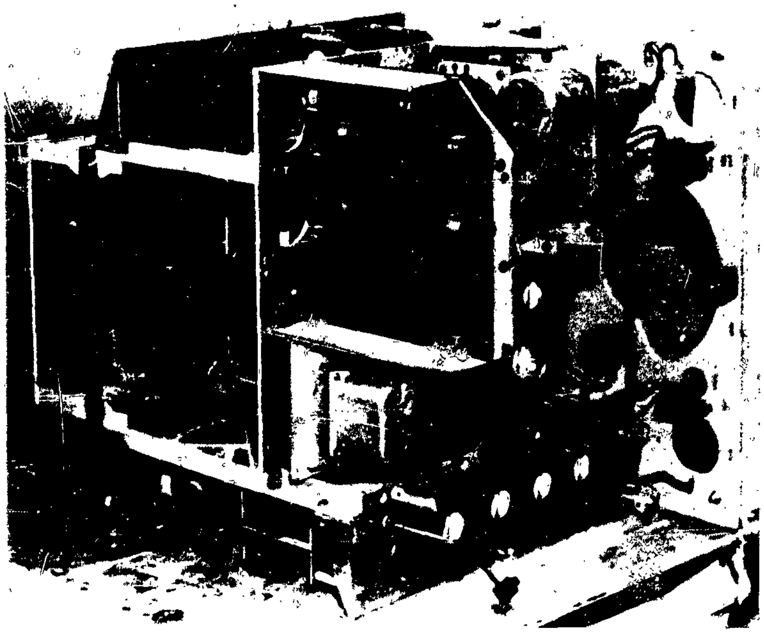


(a) - Appearance before cleaning

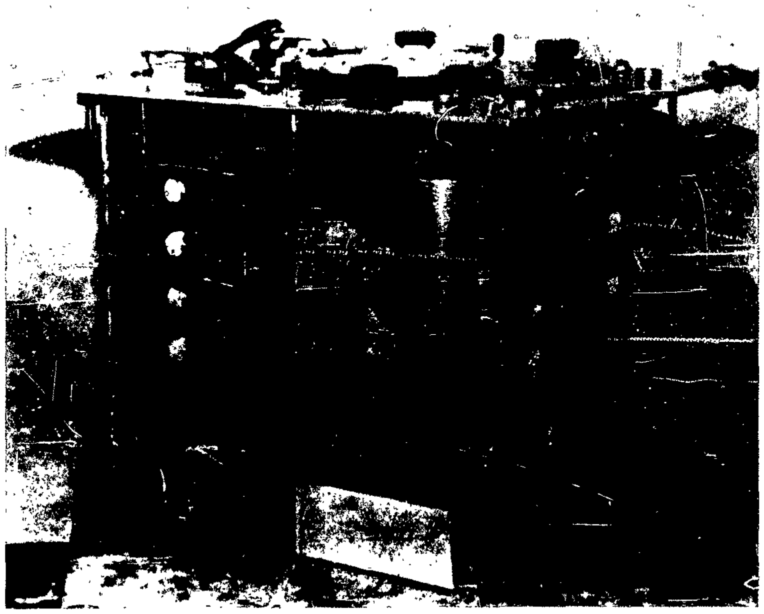


(b) - Appearance after cleaning

Fig. ? - Radio receiver damaged by fire and smoke. (Pictures courtesy of Material Laboratory, New York NAVSHIPYD.)



(a) - Appearance before cleaning



(b) - Appearance after cleaning

Fig. 3 - Electronic assembly damaged by smoke, soot, and sea water

treatment with the water-displacing liquid, was removed from the ship and stored in available shop space, from which it was moved to the restoration location as required. Covers were removed from the equipment to gain access to the electronic components, but the assemblies were submerged and cleaned without disassembly. The steps in the line for production reconditioning were:

(1) A pretreatment tank, containing 2 percent sodium polyphosphate solution agitated by immersible transducers.

(2) A large Westinghouse ultrasonic tank containing NRL neutral emulsion cleaner.

(3) Flush tank, containing fresh water agitated by the immersible transducers.

(4) Water-displacement hood.

(5) Drying oven.

(6) Bench test facility for electrical checking of recovered equipment.

No extra personnel were hired by the shipyard for the salvage operation. The electronic technicians of shop 67 alternated between operation of the recovery line and electrical checking of the salvaged items. Delays in the delivery and installation of equipment deferred the beginning of full scale recovery operations until about February 15, 1961, although a smaller crew worked on the development of techniques and the salvage of small items in small units of borrowed electronic equipment from January 15 to February 15, 1961. The salvage program was completed during the week of March 27, 1961. During this time approximately 600 electronic assemblies and more than 100 other items of electrical equipment were salvaged and returned to service. Of about 300 electronic assemblies that had been declared unsalvageable during the original survey of fire damage, approximately 90 percent were completely recovered. The following list shows some of the types of equipment salvaged:

AN/SPS-37A Radar System

AN/SPN-8 Radar System

AN/URR-35A UHF Radio

TED-9 UHF Radio Transmitting Equipment

AN/GRC-27A UHF Radio

AN/SRR-11 Radio Receiver

AN/SRA-12 Antenna Filter Assembly

AM/215D/U Antenna Patch Panel

AM/1701/URN Amplifier-Modulator

R-390A/URR Radio Receiver

Fire Control SWBD (J-switches)

AN/ARC Transreceiver

AN/SRN-6NAVGL AIDS System.

Many other pieces of equipment with minor contamination on cabinet exteriors were cleaned aboard the ship. It was observed that when equipment cases were fitted with metal mesh particulate filters and the front panels were sealed to the case with rubber gaskets the smoke contamination inside was much reduced. The filters themselves were readily cleaned in the regular salvage process. It is not easy to estimate the money value of the savings effected by this program, but it is certainly large. It is known that the prompt and extensive recovery of this damaged electronic equipment has been an important factor in reducing by five months the delay originally estimated to have resulted from the fire. This saving in time represents large cash savings, but is of still greater importance to the national security.

The costs of the recovery operation can be approximated more readily than the exact savings. The total cost for cleaning and water-displacing chemicals was about $500. Other costs would be the purchase price and installation of the ultrasonic cleaning equipment, salaries and travel of NRL personnel, and salaries of the shipyard personnel assigned to the salvage operation. The total cost is estimated to be $50,000 to $60,000. About half of the total cost was spent for the ultrasonic cleaning equipment which remains as an operating installation at the New York Naval Shipyard.

RECOVERY OF AIRBORNE RADAR EQUIPMENT AFTER SALT-SPRAY ACCEPTANCE TESTS

Other field experience in the reconditioning of electronic equipment after exposure to salt water was obtained in connection with the acceptance of the Airborne Missile Control System, Aero 1A Radar (AMCS) after the salt-spray environmental test. Although suitable equipment is capable of passing this test, experience has shown that salt retained in crevices and narrow clearances causes progressive corrosion and eventual failure of components, especially in humid exposures. Hence, equipment which has been subjected to the salt-spray test must be written off insofar as later practical usefulness is concerned.

Following a demonstration of the salvage procedure, Mr. Giuliani (5) thought that the NRL salvage procedure might be successful in removing salt traces from the AMCS radar after salt-spray testing and thus preserve a $100,000 piece of equipment for operational use.

A procedure was agreed upon whereby the AMCS would be broken into subunits, each to be given a 50-hour salt-spray exposure at 120°F, flushed with fresh water, dried with warm air, and returned to an otherwise operable assembly for electrical test. After this electrical check, which was completed in from 2 to 26 days after termination of the salt-spray exposure, the equipment was to be reconditioned by the NRL salvage procedure, including ultrasonic agitation of the cleaning solutions.

This plan was carried through essentially as outlined, and the results of the trial have been reported from the electronics viewpoint by Giuliani, Halcombe, and Leach (6). Summarized briefly, their findings were:

(1) The NRL cleaning procedure did no detectable damage to the electronic equipment, although it was essential to clean certain switch contacts after application of the heavily rust-inhibited water-displacing liquid.

(2) The cleaning procedure effectively prevented further corrosion from salt residues. The equipment has since been operated daily and observed in the laboratory for over three months. During this time it has shown no failures attributable to salt corrosion after the reconditioning treatment.

(3) The ultrasonic treatment removed corrosive soldering compounds and loosened cold solder joints not previously detected, thus permitting their correction and making the operation more reliable than before the application of the NRL procedure.

(4) The total expense for replacement components was less than one percent of the original cost of $100,000 for the system.

Personnel assisting in the reconditioning work noted that the ultrasonic exposure was remarkably effective in removing salt corrosion products from aluminum and brass surfaces. Although no oily contamination was present the emulsion cleaner was still essential because of its ability to loosen and suspend such corrosion products. However, a much lower proportion (10 percent) of the concentrate in water was sufficient in the absence of oil and grease. The results of the recovery procedure are illustrated in Figs. 4 and 5.

TECHNICAL ADVANCES IN THE SALVAGE PROCESS RESULTING FROM FIELD TRIALS

The active participation of the NRL investigators, who devised the salvage procedure, in both the AMCS and the CONSTELLATION operations provided an unusual opportunity for evaluating performance and modifying techniques to meet the practical requirements of field use. Problems encountered and the technical solutions developed are summarized below:

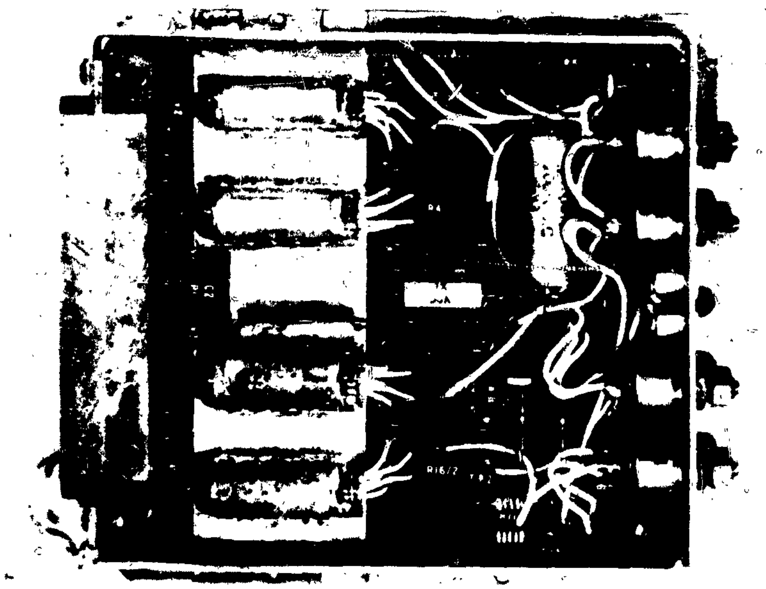
(1) Circumstances frequently prevent immediate salvage operations. In consequence metal parts corrode, oil and grease contamination dries to a hard varnish, and solid salt is deposited at inaccessible locations by evaporation of the salt water. The equipment damage is thus made much more severe, and the difficulty of cleaning is increased several fold.

When delay in salvage is unavoidable, the equipment should be flushed off with an abundance of fresh water at the earliest opportunity and sprayed with water-displacing liquid containing 3 percent of basic barium dinonylnaphthalene sulfonate. This treatment eliminates much (but not all) of the salt contamination and reduces corrosion both by depositing a water-resisting film and by neutralizing traces of acid. This procedure was used for equipment on the CONSTELLATION. It made successful recovery possible even after three months of storage before cleaning. However, the difficulty of recovery increased as the time until cleaning grew longer, and more recourse to aggressive cleaning agents was required.

(2) Hardness of the fresh water supply was noted to affect the stability and effectiveness of the cleaning emulsion. This difficulty can be controlled by treatment of the water to be used in the cleaning emulsion before adding the other ingredients. To minimize electrolyte residues on the cleaned equipment, the water treatment should use the minimum amount of softener or chelation agent that will give a satisfactory cleaning emulsion. New York City water was satisfactory after treatment with 3 ounces of tetra sodium ethylenediaminetetraacetate per 100 gallons of water. This chemical is commercially available under the trade-name "Versene," marketed by the Dow Chemical Company, or under the trade-name "Sequestrene," marketed by Geigy Industrial Chemicals Company.

(3) The use of a cleaning emulsion containing 50 percent of 140°F flash naphtha requires fire safety precautions that sometimes complicate operation of a large-scale cleaning line.

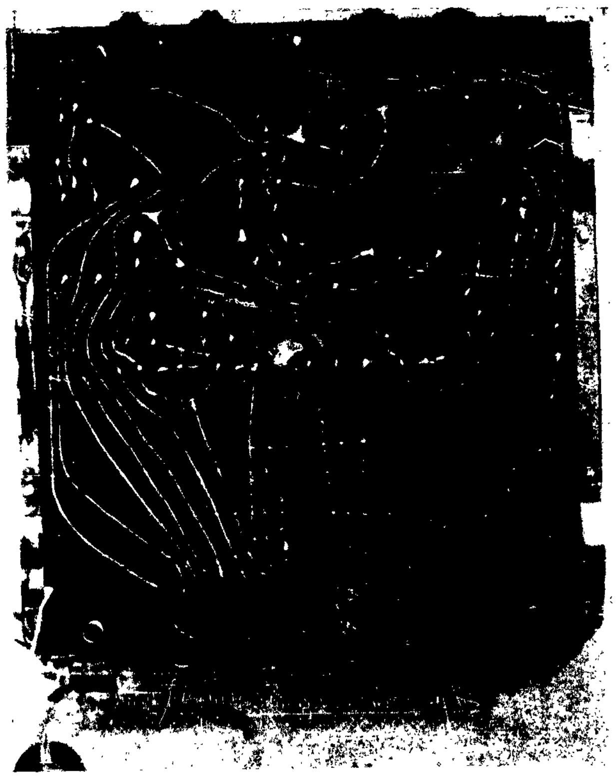
(a) - Appearance before cleaning



(b) - Appearance after cleaning

Fig. 4 - AMCS (Aero 1A Radar) electronic module damaged by salt spray

(a) - Appearance before cleaning



(b) - Appearance after cleaning

Fig. 5 - AMCS (Aero 1A Radar) printed circuit damaged by salt spray

It has been found that equipment with only minor oil or grease contamination can be cleaned effectively with emulsions containing 10 to 20 percent of hydrocarbon concentrate. This reduces the total amount of flammable material in the system. The presence of at least a small amount of hydrocarbon phase gives a distinct improvement in penetration and cleaning effect over solutions containing only water and detergent.

(4) For compactly designed military electronic equipment in which the components are crowded into the smallest volume possible, ultrasonic agitation is essential for effective cleaning of corroded or fire-damaged equipment. This results from narrow clearances which make critical parts inaccessible to the direct action of spray or stirring currents. Such agitation not only circulates liquids to inaccessible crevices but it loosens most of the gross corrosion products and removes oxidized oil or smoke films that have been softened by suitable pretreatment.

It should be emphasized that ultrasonic treatment is not required for the salvage of less complex assemblies such as electric motors, switching gear, and machine tools. In an emergency it is also possible to restore some flooded electronic equipment to operability by thorough spray treatment and flushing if ultrasonic devices are unavailable.

In general, it was found that ultrasonic cleaning equipment possessing higher energy output per gallon of liquid capacity gave faster, more efficient cleaning than units of lower energy output. The latter may be used, but more time will be required to achieve the same degree of cleaning. If ultrasonic cleaning units having different energy output per gallon are available, that possessing the highest energy output should be used for the neutral cleaning emulsion and those with lower energy output for the pretreatment with aggressive cleaning solutions and the fresh-water rinse tank.

(5) The water-displacing composition carried 3 percent of basic barium dinonylnaphthalene sulfonate as a rust inhibitor for steel surfaces. When this preparation is used on electronic equipment containing switch contacts having low contact pressure or no wiping action, the film of sulfonate left after evaporation may interfere with good switch conductance. This film may be removed from switch contacts by wiping them with a hydrocarbon solvent or isopropyl alcohol. However, electronic equipment usually contains little corrosion-susceptible steel or iron, so that the 3 percent sulfonate concentration is not needed. Satisfactory water displacement can be obtained with a water-displacing liquid containing 0.5 percent of basic barium dinonylnapthalene sulfonate.* It is even possible to use n-butyl alcohol alone as the water displacer, although with some sacrifice of efficiency and later moisture resistance of the recovered equipment.

Caution: The water-displacing composition containing a high percentage of rust inhibitor should always be employed for the initial protection of equipment to be cleaned at some later time. Sulfonate films applied at this time will be completely removed by the emulsion cleaner during the later reconditioning.

(6) Aggressive cleaners may be required for the removal of resistant contamination on fire-damaged or use-contaminated equipment, or of adherent corrosion products.

Commercially available high-alkalinity cleaning compounds, based on sodium polyphosphates and silicates, in a solution of 2 ounces per gallon (maintained at about 140°F) have been found to provide a good general purpose pretreatment. Such solutions were not found to damage insulation or electronic components during dip exposure of two minutes or less with ultrasonic radiation.

*A commercial formulation containing 0.5 percent basic barium dinonylnaphthalene sulfonate is being contemplated.

Sulfamic acid (2 ounces per gallon), with a suitable inhibitor to reduce direct attack on metals, has been found effective for removing green corrosion stains from brass parts. The corroded unit should be dipped for about one minute under ultrasonic radiation, then rinsed in a neutralizing bath kept mildly alkaline with ammonium hydroxide prior to subjecting the entire assembly to the regular salvage procedure.

Thickened paint-stripping solutions, which can be brushed on appropriate surfaces and flushed off with water, are also useful, although care is needed to protect insulation from paint-stripping compositions. A commercial preparation which utilizes methyl chloride and methanol, and which contains a thickener to enable the solution to cling to vertical surfaces of equipment, has been found useful. After a few minutes application the paint and excess chemicals may be washed from the equipment with alkaline aggressive cleaner solution. The equipment is then rinsed thoroughly with fresh water and subjected to the regular salvage procedure.

(7) The temperature of cleaning baths and of the drying oven or drying air should be kept below 125°F to avoid damage to transistors and diodes if these are present.

(8) For production line treatment of electronic assemblies, drying in an adequately ventilated low temperature oven for 16 hours or longer has been found adequate. Drying for less than eight hours may not be sufficient to remove final traces of the water-butyl alcohol azeotrope.

CONCLUSIONS AND RECOMMENDATIONS

(1) Surface chemical salvage procedures have been shown to be effective and profitable for the large scale recovery of equipment after exposure to fire, smoke, and water contamination.

(2) The applicability of the procedure can be significantly extended by the use of suitable aggressive cleaners as a pretreatment; residues from such chemicals are effectively removed if the treatment is followed by the usual emulsion cleaning, flushing, and water displacing. Further work should be done to identify acceptable cleaning agents and to define proper conditions for their use.

(3) The success encountered in the field applications indicates promise for these salvage techniques in other operating situations which are listed herewith:

(a) Recovery of electronic, electrical, and mechanical components of aircraft after forced landings on water.

(b) Recovery of missile components after over water test firing and recovery. The method may also be useful in reconditioning oceanographic equipment which has been accidentally or intentionally exposed to salt water.

(c) Reconditioning of shipboard equipment after compartment flooding or battle damage.

(d) Salvage of industrial machinery, small motors, etc., after flood disasters in industrial areas.

(e) Routine reconditioning of electronic equipment exposed to tobacco and other aerosol contamination, as in long-submergence submarines. The method has also shown promise for routine cleaning of teletype machines, typewriters, and calculators with a minimum of disassembly.

(f) The water-displacing liquid can be conveniently applied to bare steel surfaces during fabrication to prevent rusting before the application of the final protective coating. The thin sulfonate film deposited is an effective rust inhibitor for several weeks and it does not interfere with manufacturing operations or the application of the final paint coating.

Naval activities should be encouraged to field test the method for such applications as the opportunity offers.

(4) The nonaqueous portion of the cleaning emulsion should be assigned a Navy stock number and made widely available in suitable containers for fleet use as a concentrate from which the emulsion can be prepared easily.

ACKNOWLEDGMENTS

The authors acknowledge with pleasure the cooperation of personnel of the Bureau of Ships and the New York Naval Shipyard in connection with the development of procedures for the salvage of equipment from the USS CONSTELLATION. The Industrial Electronics Division, Westinghouse Electric Corporation and the Harris Transducer Corporation made helpful technical information available in the same connection.

Representatives of the Radar Division of this Laboratory, the Bureau of Weapons, the Industrial Electronics Division, Westinghouse Electric Corporation and the contractors, the Air Arms Division, Westinghouse Electric Corporation, and Raytheon Manufacturing Company made important contributions in the salvage of the AMCS, Aero 1A Radar.

REFERENCES

1. Baker, H.R., and Leach, P.B., "Salvage of Flooded Electrical Equipment," NRL Report 5316, June 1959

2. Baker, H.R., Leach, P.B., Singleterry, C.R., and Zisman, W.A., "Surface Chemical Methods of Displacing Water and/or Oils and Salvaging Flooded Equipment, Part 1 – Practical Applications," NRL Report 5606, Feb. 1961

3. Baker, H.R., and Zisman, W.A., "Water-Displacing Fluids and Their Application to Reconditioning and Protecting Equipment," NRL Report C-3364, Oct. 1948

4. "Salvage of Flooded Electronic and Mechanical Equipment," BuShipsInst 4740.3 Ser 634A-23, Jan. 19, 1961

5. Giuliani, J.J., Radar Division, Naval Research Laboratory

6. Giuliani, J.J., Halcombe, D.A., and Leach, P.B., "Reclamation of AMCS (Aero 1A Radar) After Exposure to Salt-Spray Environmental Tests," NRL Memo.Rept. 1175 (Confidential), June 1961

APPENDIX A

CLEANING EMULSION FORMULATION

The cleaning organic solvent concentrate is formulated as follows:

89.0 vol-% 140°F flash point aliphatic solvent

Navy Stock No., heavy duty 55-gallon drum, W6850-281-1986

or Navy Stock No. lightweight 55-gallon drum, W6850-285-8011

or Navy Stock No. 5-gallon can, W6850-274-5421

10.0 vol-% diesel fuel

Navy Stock No., 5-gallon can, WF9140-255-7764

1.0 vol-% polyethyleneglycol 400 monooleate S1006, available from Glyco Products Co., New York, N. Y.

This concentrate is emulsified with water in proportions of from 10 to 50 vol-% depending upon the degree of oily contamination being removed. For maximum contamination use 50 vol-% concentrate and for low or no oily contamination use 10 vol-% of concentrate.

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2. Electric equipment – Salvage
3. Surface active agents – Applications

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